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# INFLUENCE OF SALINITY ON UPTAKE RATE AND BIOACCUMULATION OF $^{137}$Cs IN THE OYSTER *CRASSOSTREA GLOMERATA*

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This paper describes results of experiment on bioaccumulation and uptake rate of radiocesium $^{137}$Cs from dissolved phase in the flesh of the Oysters (*Crassostrea glomerata*) collected off Karachi coast. A radiotracer experiment was conducted under laboratory conditions to determine the uptake rate and bioaccumulation of $^{137}$Cs from dissolved phase in the flesh of the Oysters. Oysters *(size:* 6–7 cm) were subjected to radiocesium activity of 24 Kilobecquerel per liter (kBq $L^{-1}$) under three salinity levels (25, 30 and 35 ppt). The uptake of $^{137}$Cs was monitored for a period of seven days. The results showed that bioaccumulation and uptake of $^{137}$Cs in oysters were considerably dependent of salinity levels. Higher bioaccumulation factors and uptake rates were found at low salinity levels.

**Keywords :** Bivalves, Oysters, Salinity, Cesium, Karachi, Bioaccumulation

## 1. Introduction

Bivalves are extensively used in monitoring programs in the marine environment due to their ability to concentrate pollutants to several orders of magnitude above ambient levels in sea water [1]. An ideal biomonitor should fulfill several requisites: should be sessile or sedentary in order to be representative of the study area; should be abundant in study area, easy to identify, should have sufficient tissues for analysis of the contaminant of interest; should be hardy, tolerating wide ranges of contaminant concentration, thereby permitting the design of transplant experiments and laboratory studies of contaminant kinetics; and should be strong accumulator of the relevant trace metal [2]. Since oysters and mussels fulfill most of these characteristics, therefore, they are being used as bio indicator organisms in environmental assessment and monitoring programs.

The bioaccumulation of various radionuclides in oysters has been examined in many studies which showed that in certain cases oysters are better metal accumulators than mussels. Oysters accumulate metals and can tolerate very high metal concentrations, without apparent detrimental effects [3,4] Oysters have a greater affinity for Ag, Cu, Cs and Zn than do mussels and are considered to be potential bioindicators for monitoring metallic pollution in marine environments [5-10].

Radiocesium ($^{137}$Cs) is among the major radionuclides released by a nuclear power plant under normal operating conditions. It exhibit contrasting behaviors, depending on the biochemical properties of the stable isotopes. Cesium is a chemical analogous to potassium that is classified among the macronutrients. Once release into the atmosphere, through natural and anthropogenic activities, radioactive cesium can travel thousands of miles before settling to earth and is removed by wet and dry deposition. These radioactive cesium isotopes also persist in the environment, with the potential for adverse health effects. Cesium has been shown to bioaccumulate in both terrestrial and aquatic food chains [11]. Because of the high potassium concentration in oceans, the transfer of $^{137}$Cs to fish is much greater in freshwater and the activity of freshwater fish may be 100 times that of ocean fish, given the same cesium concentration in the water [12].

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Salinity also appears to be a natural factor influencing metal accumulation in marine organisms [13]. It has been reported that Ag, Cu, and Zn accumulation are inversely related to salinity under conditions of constant total metal concentration [14-16]. In the present investigation, bioavailability of $^{137}$Cs in marine oysters at different salinity ranges were examined. The objective was to determine the influence of salinity on the capacity of the oyster to bioaccumulate $^{137}$Cs, known to be contaminant of concern in the Karachi area [16]. Salinities tested in the experiment represent the ranges actually encountered in the coastal waters of Karachi and the experimental work was carried out using state-of-the-art nuclear techniques and gamma-emitting radiotracers ($^{137}$Cs). For this purpose the oyster species namely, *Crassostrea glomerata,* commonly found along Karachi coast was selected this exhibits an unusually great capacity to accumulate a range of elements from the ambient environment and it appears to be a reliable indicator organism, and may be of great value in global monitoring studies [17].

## 2. Materials and Methods

### *2.1. Sampling*

About 200 Oysters of size 6-7 cm were collected manually from the same bed and at same tidal level (low tide) from Sunari, Karachi Coast in February 2007. The collected organisms were placed in plastic bags containing seawater from the sampling location and transported to PINSTECH laboratory in Islamabad. Oyster shells were thoroughly washed with seawater in order to remove their fouling organisms and were acclimated to laboratory conditions (closed circuit aquaria, temperature 29 ± 1°C, salinity 35 ppt) for one week prior to the experiment and fed daily with a mixture of phytoplankton namely: *Ankistro-desmes* and *Navicula.*

### *2.2. Experimental setup*

The experiment was carried out using 0.22µm filtered seawater in 8-L polyvinyl aquarium equipped with a small sized circulation pump and an air pump. Salinity levels were adjusted as required by adding 0.22µm filtered distilled water and temperature was controlled by a 300-W aquarium heater (Life Tech brand, model 2010) and a constant water circulation. Salinity levels were measured with the help of salinity meter (Jenco, Model 3250 Conductivity /Salinity Meter). For each salinity condition, the oysters were acclimated to the specific conditions for one week prior to the actual experiment. Three aquarium were used for three selected salinity levels and 50 oysters were placed in each aquarium. The experimental seawater of each aquarium was spiked with µL quantities of radiocesium in the form of CsCl-HCl to reach a final activity of 24 kBq $L^{-1}$. The pH of the experimental medium was 8.1.

### *2.3. $^{137}$Cs analysis*

At different times, water samples and three oysters were collected from each aquarium. The organisms were briefly rinsed with clean seawater, blotted dry, weighed, and dissected into shells and soft parts. The dissected parts were weighed (wet wt) and radioanalyzed using a high-purity Ge-Li gamma spectrometer (Canberra GC 3020 coaxial type, relative efficiency 30% with $^{60}$Co peak resolution of 2 KeV at 1.3 MeV) for five minutes. The activity of all the samples was compared with $^{137}$Cs standards of appropriate geometry and corrected for physical decay. The counting times were adjusted to yield a propagated counting error of <5%.

### *2.4. Uptake rate and $^{137}$Cs bioconcentration factor calculation*

Bioconcentration Factor (BCF), also known as Bioaccumulation Factor (BF), is taken as the ratio of $^{137}$Cs concentration in the oysters flesh wet weight (Bq $gm^{-1}$) to $^{137}$Cs concentration in the dissolved phase (Bq $mL^{-1}$) and expressed as ml $gm^{-1}$or L $Kg^{-1}$. By applying the BCF concept to marine organisms it is assumed that the metal concentration in the organisms is at steady state with the concentration in the surrounding water and that the uptake of the metal is in proportion to its concentration in the seawater [18]. The uptake rate was calculated by the slope of the linear regression between $^{137}$Cs concentration in oysters and time of exposure and it is expressed as change in BCF over time (µg $g^{-1}h^{-1}$).

## 3. Results and Discussion

$^{137}$Cs activity at different salinity levels is shown in Table 1. The uptake kinetics of $^{137}$Cs were determined in the soft tissues of oysters exposed for 168 hrs under different salinity conditions (25, 30 and 35 ppt). The data presented in Fig.1 shows a saturation kinetic pattern for the three salinity conditions. The uptake (slope of regression between bioaccumulation and time) was considerably affected by ambient salinity. Uptake rate decreased significantly with the

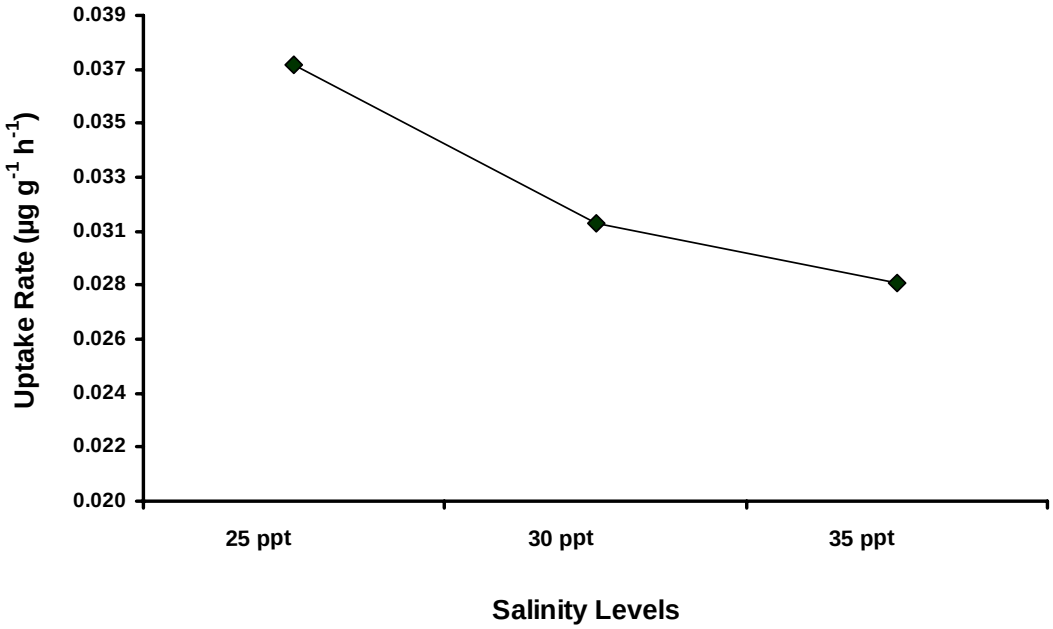


Figure 1. Uptake rate of $^{137}$Cs in Oysters at different salinities levels

Table 1 $^{137}$Cs concentration in oyster flesh.

| Time (hrs) | 25ppt | | 30ppt | | 35ppt | |
|---|---|---|---|---|---|---|
| | Sample weight (gm) | $^{137}$Cs Conc. (Bq / Sample) | Sample weight | $^{137}$Cs Conc. (Bq / Sample) | Sample weight | $^{137}$Cs Conc. (Bq / Sample) |
| 2 | 2.68 | 59.34 | 2.42 | 28.97 | 3.54 | 8.99 |
| 4 | 5.2 | 119.08 | 5.17 | 74.45 | 5.55 | 20.54 |
| 6 | 7.86 | 181.25 | 6.52 | 93.37 | 5.18 | 29.89 |
| 8 | 7.62 | 195.00 | 7.02 | 109.93 | 2.54 | 35.36 |
| 10 | 6.59 | 174.96 | 7.33 | 118.38 | 5.27 | 99.08 |
| 12 | 5.59 | 207.39 | 8.53 | 132.13 | 6.87 | 128.47 |
| 24 | 7.07 | 231.40 | 6.22 | 154.07 | 6.9 | 206.31 |
| 48 | 4.96 | 255.44 | 6.13 | 217.06 | 7.43 | 215.40 |
| 72 | 5.24 | 281.07 | 6.55 | 232.92 | 6.22 | 279.40 |
| 96 | 5.53 | 301.05 | 6.77 | 286.24 | 6.24 | 278.68 |
| 120 | 7.25 | 375.26 | 6.78 | 351.88 | 6.07 | 283.47 |
| 144 | 5.81 | 322.92 | 6.78 | 352.56 | 7.64 | 356.79 |
| 168 | 6.12 | 316.77 | 8.25 | 306.44 | 6.81 | 318.03 |

increase in salinity level. The ratio of $^{137}$Cs uptake rate (µg g$^{-1}$ h$^{-1}$) in flesh of *Crassostrea glomerata* was found to be 1.3:1.1:1.0 at 25, 30 and 35 ppt. respectively at the end of the experiment. Uptake rate at 25 ppt was 1.3 times higher as compared to the uptake rate at 35 ppt (Table 2).

$^{137}$Cs BCF in the oyster flesh at 25, 30 and 35 ppt through dissolved phase is shown in Fig. 2. At 25 ppt, steady state was achieved at 96 hours and a slight decreasing pattern was followed after 120 hrs. No systematic trend was observed in bioaccumulation factor at 30 ppt, the BCF showed an increasing trend upto 72 hrs followed by a steady state upto 96 hours, again increasing trend upto 144 hours and then sharp decline till the end of the experiment.

Bioaccumulation Factor at 35 ppt showed quite irregular pattern, an increase upto 24hrs and then steady state was observed till 72 hrs and then again an increase upto 144 hrs followed by a sharp decline.

Table 2. Uptake rate and initial sorption rate of $^{137}Cs$ in *Crassostrea glomerata* flesh at different salinity levels.

| Salinity Levels (ppt) | Uptake rate ($\mu g\ g^{-1}h^{-1}$) | Initial sorption ($\mu g\ g^{-1}$) |
|---|---|---|
| 25 | 0.037 | 1.633 |
| 30 | 0.031 | 1.38 |
| 35 | 0.028 | 1.05 |

It is well known that organisms living in lower salinity waters generally contain higher concentrations of metals than those living in waters of higher salinity [19]. Various mechanisms have been proposed to explain salinity effects, including change in metal speciation and physiological conditions of the mussels such as the pumping rate, or change in cell volume and permeability [20-22]. As regard metal speciation, salinity influences directly the concentration of free metal ion, which is the most bio-available chemical species [23]. However, changes in concentration of the major cations (e.g. $Ca^{++}$ and $Mg^{++}$) in seawater can also influence metal uptake by changing the permeability of the epithelial structures, competing for 140 binding sites with the apical membrane surfaces, and decreasing metal transfer from the epithelium to the blood with increasing intracellular levels of calcium [24-27]. Therefore, the influence of salinity on the Cs influx rate is probably due to the combined effects of speciation change (related to change in chloride anions) and change in binding competition (related to major cations).

The uptake rate generally decreases until a steady state is reached between the metal in the water and in organism tissues. In larger organisms, internal tissues are often isolated from the surrounding water, with longer equilibration times for surface metal sorption from water (days to weeks) compared to small species such as mussels. The importance of the initial component of uptake depends to some extent on the surface characteristics of the organism. Hard-shelled, calcareous animals can deposit appreciable amounts of metal in the shell during growth, whereas soft-bodied organisms with no hard external covering are able to equilibrate their internal tissues more rapidly. The sorption of metals from water to organism surfaces is typically greater in smaller organisms since the role of surface area in total accumulation is of far less importance in larger species that have a low surface area to volume ratio [28].

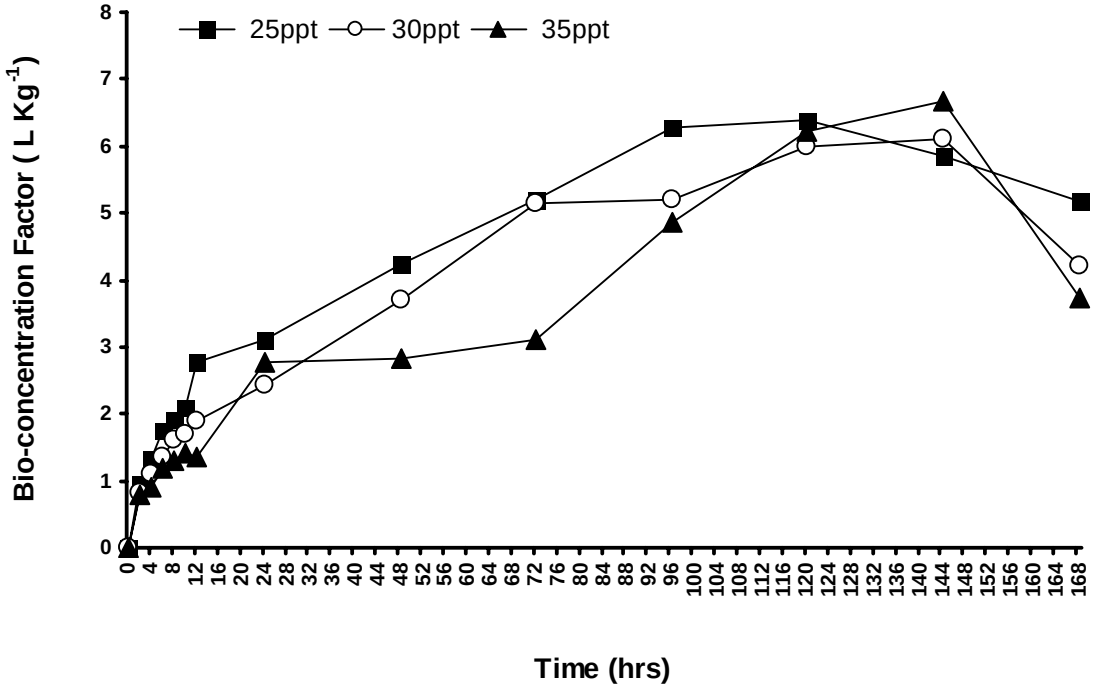


Figure 2. $^{137}Cs$ Bio-concentration Factor (BCF) in soft tissues of oyster over time at different salinities.

Salinity affects metal levels in both sea water and marine organisms [13]. Our study also indicated that Cs uptake was considerably affected by ambient salinity, consistent with many previous observations on the effect of salinity on metal accumulation [29, 30]. In the present investigations uptake rate of Cs is increased by 1.3 times when the salinity was changed from 35 ppt to 25 ppt which is quite in agreement with the results cited by Phillips [19]. According to his results, the uptake rate increased by 1.5 times at 15 ppt as compared to 33 ppt salinity conditions in green mussels. Similar results were observed for uptake of metals by marine algae. Chan *et al*. [31] measured the uptake kinetics of four metals (Cd, Cr, Se and Zn) in two marine macroalgae (seaweeds variety: green alga *Ulva lactuca* and the red alga *Gracilaria blodgettii*) at different salinity levels and observed that the decrease in salinity from 28 to 10 ppt enhanced the uptake of Cd, Cr, Se and Zn in *U. lactuca* 1.9, 3.0, 3.6 and 1.9 fold, respectively. In *G. blodgettii*, Cd uptake increased twofold when salinity was decreased from 28 to 10 ppt.

## 4. Conclusions

The present study has clearly shown that bioconcentration of dissolved $^{137}Cs$ in the soft tissues of the oysters (*Crassostrea glomerata)* is significantly affected by changes in salinity. Therefore, this parameter can be used to understand and predict metal bioaccumulation in natural conditions and for interpreting reliably the data of field monitoring studies. Furthermore, the ability of oyster *Crassostrea glomerata* to accumulate radiocesium in soft body parts can also be utilized for bio monitoring studies along Karachi coast.

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